PATENT
SAA-36

# UNITED STATES PATENT APPLICATION

of

Richard A. Baker, Jr.

for

# NETWORK ADDRESSING BASED ON PHYSICAL SITE LOCATION OF A NETWORK DEVICE



EXPRESS MAIL NO. EL 508 861 755 US

# NETWORK ADDRESSING BASED ON PHYSICAL SITE LOCATION OF A NETWORK DEVICE

## Field of the Invention

The present invention relates generally to a method for communication among a plurality of devices in a communications network. In particular, it relates to establishing the address for each device.

## Background of the Invention

A local area network system, such as the Ethernet, can be used for industrial control applications. Such a network system can be used to enable programmable controllers, host computers, control devices such as adjustable frequency drives, and other devices to communicate through the production areas of an industrial plant. The devices connected together in such a communication link are generally referred to as "nodes". Each node has a unique Media Access Control (MAC) address as an identifier of the node to allow messages from one node to be sent to another.

In an automation factory where a plurality of automation devices are used to perform a variety of intended functions, each automation device has a controller, such as a programmable logic controller (PLC), to communicate with a controlling workstation or the PLC of another automation device. Furthermore, the PLC includes a software program to control the automation device in performing the intended function. It is quite common that the automation devices are placed at physical site locations in accordance with their particular functions. Conventionally, each of the automation devices is identified by the MAC address (or an Internet Protocol (IP) address) given to the PLC of the automation device. The MAC address is a fixed address which is given to an Ethernet module of a PLC when it is manufactured or assigned by a user, and the MAC address is unrelated to the physical site location of the device. If the PLC at one location is replaced by another PLC, the device at that particular location will not operate until the new MAC address of the replacement PLC is associated with the old MAC address of the replaced PLC. This

addressing method is disadvantageous in a factory automation setting. If a problem develops with the device, maintenance must be performed by a professional who is skilled in networking management in order to associate the new MAC address with the old MAC address. This method is costly and can be time consuming.

It is, therefore, advantageous and desirable to provide a method and a network system wherein the need for the network management professional to be available for replacement of the factory device can be eliminated.

Summary of the Invention

One aspect of the present invention is a method of network addressing based on the physical site location of the network devices. The method includes the steps of identifying the physical site location of a network device and associating the physical site location to the device address so as to allow the device to communicate with other devices in the network.

Another aspect of the present invention is a network communications system having a plurality of devices, wherein one or more devices include means for identifying the physical location so that the physical location is used as an address of the device in order to allow the device to communicate with other devices in the communication system. Preferably, a software program is used to convert a map of physical locations of the devices into an address table required for routing messages to these devices.

Accordingly, a further aspect of the present invention is a device to be used in a network communications system wherein the device includes means for identifying its own physical location so that the physical location can be used as an address of the device in order to allow the device to communicate with other devices in the network communications system.

The present invention will become apparent upon reading the descriptions taken in conjunction with Figures 1-4.

Brief Description of the Drawings

Figure 1 is a block diagram showing a network communications system.

Figure 2 is a block diagram showing a network device.

Figure 3 is a block diagram showing a network communications system wherein a plurality of network devices share one physical location.

Figure 4 is a block diagram showing a mapping method for relating a physical location to the address of a network device.

Detailed Description of the Invention

The network communications system of the present invention is shown in Figure 1. As shown, the communications system **10** includes a plurality of network devices **101-105**. Each of the network devices **101-105** is placed at one of the different physical locations **201-205**, connected by a communication link **20**. As shown in Figure 2, each device has a controller such as a programmable logic controller (PLC) **116** for controlling the device in carrying out the intended function thereof. Preferably, the communications system **10** is a modified local area network (LAN) wherein the address of each device to be used for communication purposes is associated with the physical site location of the device, rather than a Media Access Control (MAC) or an Internet Protocol (IP) address that is usually given to a PLC or to an input device of a PLC system. The network communications system can be any wired or wireless network that uses electrical signals, optical signals or other form of message signals to convey messages between devices in the system. The network communications system can also include one or more wide area networks (WANs). One of the network devices **101-105** may be a workstation or a master module to oversee the overall operations of the network communications system.

Figure 2 shows the components in a typical network device **100**, representative of the network devices **101-105** shown in Figure 1. As shown in Figure 2, the network device **100** includes an I/O interface **122** for exchange signals or data with a machine or a monitoring apparatus; a network interface **112** to exchange signals or data with other

network devices in a network communications system; a physical site locator **114** residing inside or outside the network interface **112** to identify the physical location of the network device **100**; and a programmable logic PLC **116** to control the machine or monitoring apparatus to which the network device **100** is connected using an application program **120** stored in a memory unit **118**. These components can communicate with each other and other network devices **100** through a bus in the backplane **124**.

In a factory automation system where a variety of automation machines are organized into a network communications system, and each automation machine is controlled by a network device **100**, each machine may have a particular function to perform. For example, one machine may perform a metal stamping function while another performs metal surface polishing in an assembly line environment. Thus, the network device **100** connected to each automation machine includes an application program **120** to control the machine. In order for the machine to carry out the intended function in a timely manner, the network device **100** must have the ability to communicate with other network devices in the system.

It should be noted that, in some applications, the machines connected to a network are required to perform different functions. But in other applications, all machines can be used to perform the same function. For example, in a pipeline where batches of refined petroleum products are transported within a transport pipe from one state to another, a number of instruments are used at different locations along the pipeline to monitor the flow rate, fluid pressure and the content of the passing batch. Thus, all the monitoring instruments and the application program therefor can be identical. The only difference is the location of the monitoring instruments. In this type of the application, it is especially advantageous to use the physical site location as the address of each monitoring instrument.

In general, when the automation factory is designed, the industrial engineer works off of a floor plan. The floor plan is refined to an individual machine and to the physical site location of the machine. This physical location becomes the identifier of the unit or the address of the network device in the communications system. Once the automation machines are installed according to the floor plan, a software program is used to tie the

location on the floor plan to the location of the automation machine as identified by the physical site locator **114** of the network device **100** to which the automation machine is connected. Because the physical site locator **114** only recognizes the location of the machine and not the function of the machine, the network device **100** connected to one machine can be identical to the network device **100** connected to another machine. Thus, all network devices **101-105** as shown in Figure 1 can be identical. Once identified, all control or application programs and configuration information needed for an automation machine placed at a particular location to perform an assigned function can be downloaded from a master module, for example, to the PLC **116** of the network device **100**. Preferably, a mapping software program is used to convert a map of the physical site locations of the network devices into one or more address tables required to route messages to these network devices. With such a mapping software program, the physical locator of a network device functions like the MAC address of the device regarding the routing of messages in a network. The mapping software will be described in conjunction with Figure 4.

If a problem develops with a network device **100** on a certain automation machine, that network device **100** can be replaced with another network device **100**. Likewise, if a problem develops with a certain automation machine, it can be replaced with another similar machine, with or without changing the network device **100**. Once the replacement is completed, the programs and configuration information can be downloaded again according to the physical site location as identified by the physical site locator of the replacement network device. Because the physical location of the automation machine remains the same, the programs and configuration information downloaded to control the automation machine will always be the same. Replacing a machine with a similar machine or replacing a network device on a machine does not require the skill of a professional in the field of network management. Thus, the maintenance of an automation factory can be greatly simplified and can be carried out in a cost-effective fashion.

As an additional benefit of the present invention, the location information in a hard wired factory can be used as a safety check to assure that the program in the PLC is intended to be operated at the location of the machine. It is not uncommon where a user

places the wrong PLC program into a PLC and the wrong PLC causes an unintended operation. By double-checking the physical location, most mistakes of this type can be eliminated.

The physical site locator **114** is known in the art. Personal locator technology, such as the Global Position System (GPS), a Time Difference Of Arrival (TDOA) device, or another Personal Locator System (PLS) can be used to identify the location of the network device **100** in which the physical site locator is included. However, each of these locator devices or systems has a location resolution beyond which the locator is unable to resolve. For example, a location resolution of 5 foot squared or better may be impractical in a factory automation setting where two or more machines are located closely together. In a different embodiment of the present invention as shown in Figure 3, one physical locator can be shared with a group of machines located in a small footprint. As shown in Figure 3, a network **10'** comprises a group of network devices **101, 105, 106, 107** and **108**, and a controlling workstation **119**. While the devices **101** and **105** are separately positioned in physical locations **201** and **205**, respectively, the devices **106-108** are located in the same physical location **206** to be associated with three machines. The shared physical locator is, for example, associated with one of the PLCs that controls the machines in the physical location **206**. Thus, not all the network devices **106-108** have to use a physical site locator **114**. However, the PLC **116** (see Figure 2) in each of the network devices **106-108** must have its own MAC address, IP address or another network address. When a PLC **116** is powered on, it learns its location from the shared physical locator and then transmits a message, providing both its MAC address and the shared physical location to the controlling workstation **109**. A software program in the controlling workstation **109** would then translate this message in order to map the floor plan with the provided MAC addresses for the associated machines. As such, the controlling workstation **109** or another device can download an appropriate application program to the PLC, and the PLC would start with the application program intended for a network device in the shared location. It is possible that the message transmitted from a PLC **116** to the controlling workstation **109** is a Reverse Address Request Protocol (RARP) message.

Whether each network device **100** is positioned in a different physical site location as shown in Figure 1, or a number of network devices **100** share a physical site location as shown in Figure 3, it is advantageous to link a map of the physical locations to one or more address tables for routing messages to or from the network devices. Such a mapping method is shown in Figure 4. As shown in Figure 4, a map **300** having six different physical locations is related to an address table **310** having six different network addresses. For example, physical location 1 is associated with network address 1, etc. Depending on the communications network, the network address can be a MAC address, an IP address or another address type. The mapping between the physical location and the network address can be carried out by a software program in the master module, for example.

The method, the network device and the network communications system, according to the present invention, can be applied to a variety of monitoring programs. For example, a utility company can use the network device associated with a power meter to remotely read out the power meter at any location without the need of identifying the power meter. The network device can be programmed to automatically convey information including its physical location and the meter reading to the utility company according to the stored instruction. Similarly, a pipeline company can monitor the flow of the feed-stock at desired locations and time intervals. A water company can monitor water usage for billing and leak detection. A mining company can use a plurality of network devices, which can be moved to different locations if desired, to report the status of air quality or water levels. Network devices can be installed along with various monitoring instruments at various locations in a building to read out local temperature, humidity, air quality, lighting condition, etc. The present invention can also be applied to home automation in a smaller scale. Again, if a problem develops with a network device, any unskilled personnel can replace the network device.

Thus, the present invention has been described with respect to the preferred embodiments thereof. It will be understood by those skilled in the art that numerous changes and deviations in the form and detail thereof may be made without departing from the spirit and scope of the present invention. For example, the network communications system as depicted in Figure 1 can be replaced by a wireless network, or a network with a

plurality of gateways and bridges. Similarly, the device as depicted in Figure 2 can be modified to include more components or to reduce the number of components. However, these variations do not depart from the scope of the present invention wherein network addressing is based, partly or completely, on the physical site location of the devices in the network.